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(54) **Method for gradually classifying driving styles and motor vehicle using this method**

(57) A method for gradually classifying driving styles between a steady driving style and a dynamic driving style in which code numbers incrementally evaluate the driving style between steady and dynamic provides for the separate determination of a code number relating to the acceleration behaviour, of a code number relating to the braking behaviour and of a code number relating to the steering behaviour. The determination preferably does not use the settings of steering wheel, accelerator pedal or brake pedal as measurement variables which are indicative of driving styles, but rather the accelerations in the longitudinal and lateral directions. This procedure permits a reliable classification of the different types of driving behaviour and a correspondingly differentiated driving-style adaptation of the open-loop or closed-loop control systems respectively present in the vehicle.

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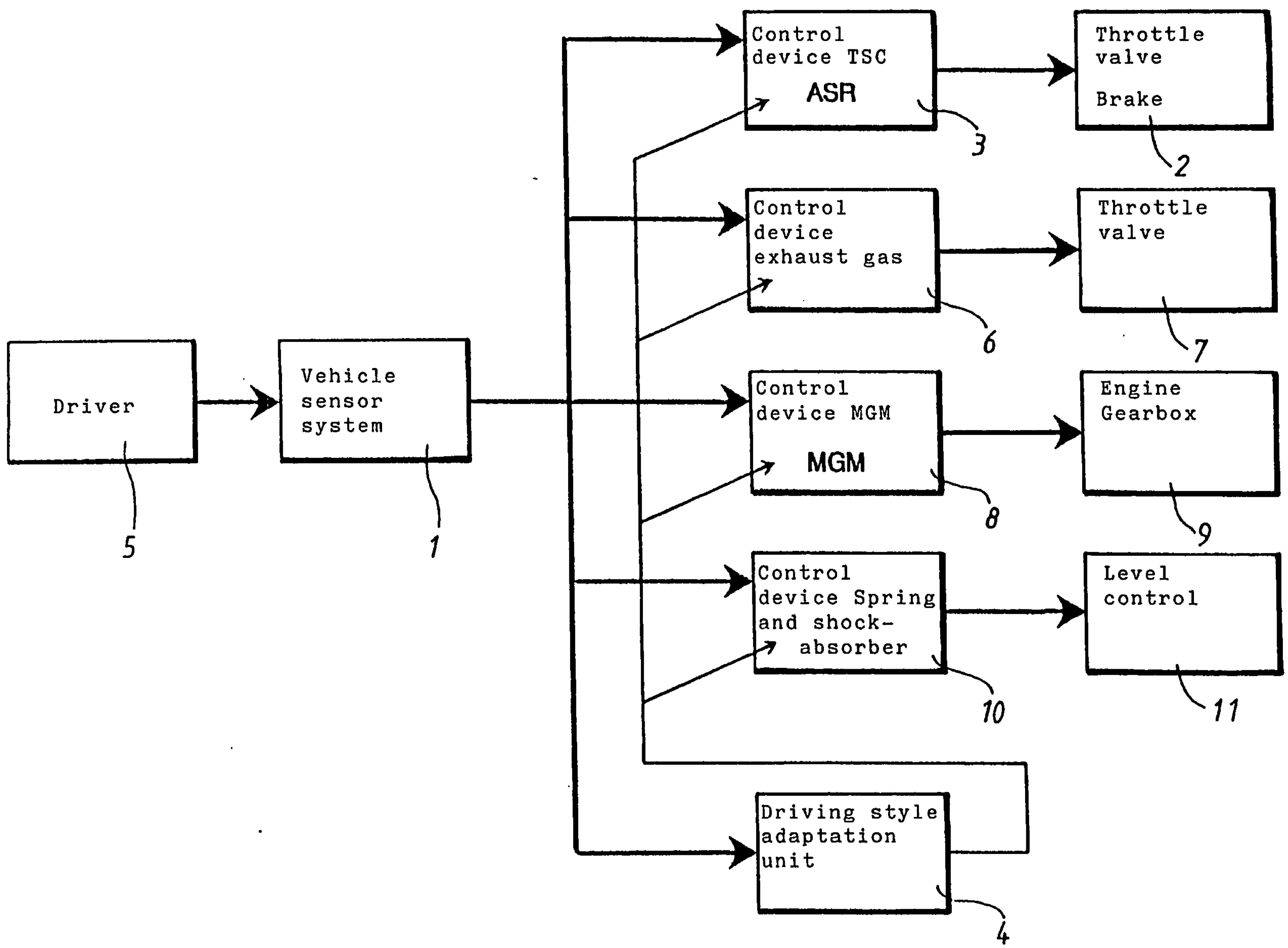
Driver
5
Vehicle sensor system
1
Control device TSC
ASR
3
Throttle valve
Brake
2
Control device exhaust gas
6
Throttle valve
7
Control device MGM
MGM
8
Engine Gearbox
9
Control device Spring and shock-absorber
10
Level control
11
Driving style adaptation unit
4

Method for gradually classifying driving styles and motor vehicle using this method

The invention relates to a method for gradually classifying driving styles between a steady and a dynamic driving style in which during driving measurement variables which are indicative of driving styles are sensed by vehicle sensor systems and at least one driving-style code number is determined by means of at least some of the detected measured values using a respectively associated measurement variable/driving-style characteristic diagram which has been stored in advance, and to a motor vehicle which uses this method for driving-style adaptation of at least one open-loop or closed-loop control system.

While early vehicle control systems were usually designed as permanently adjusted logic elements, it is known to use open-loop or closed-loop control systems which are capable of driving-style adaptation for modern motor vehicles. Thus, a given motor vehicle can be individually adapted to the driving style preferred by the respective user by means of a corresponding adaptation of the input parameters of the open-loop or closed-loop control system in relation to the vehicle function which is influenced by the said system. For a driver who prefers a rather steady driving style, for example the vehicle can behave with the emphasis on comfort and/or with optimized consumption while, when used by a driver with a rather dynamic driving style, it can be adjusted to sporty driving behaviour.

With an engine control system with adaptive driving style, known from the Patent Application US 4 853 720, the desired driving style can be set by means of a selector switch to one of the three variants: sporty, comfort-oriented or consumption-oriented. The engine is then controlled as a function of this setting and of selected measured values of the vehicle sensor system.

In control systems, known from the Offenlegungsschrift DE 38 17 495 A1, for electronically controllable vehicle

functions, such as e.g. controlling the seat setting or controlling the engine, it is also possible to adapt these functions to the behaviour of the respective user. Here, the behaviour of the user is not strictly prescribed externally but instead is learnt by the system itself by detecting the actuations of the various vehicle elements performed by the user over time. In order to adapt an engine control it is monitored here when the user changes gear manually and in what manner he actuates the accelerator pedal in each case, the instantaneous vehicle speed and acceleration being simultaneously detected. The data received can be compared by a processor unit with data stored in advance for a number of categories of possible driving styles and the respective user can be correspondingly placed in a specific category of driving style. This category can be assigned a code which the processor unit detects and according to which the engine control is set as a function of the driving style assigned to the user.

A further method for classifying driving styles and a method for a motor vehicle using an engine control is disclosed in the Patent US 5 189 621. Here, inter alia, the measurement variables of vehicle speed, speed of engine angle, throttle valve angle and speed of throttle valve angle are detected during driving by appropriate sensor systems. By means of a fuzzy logic evaluation, one of three provided types of driving style, namely a normal, active or sporty driving style, is assigned to these detected measured values. The behaviour of the engine control is then set as a function of the detected driving style and, if appropriate, also of detected ambient conditions of the vehicle, e.g. driving in a traffic jam or on a motorway. For this method, rapid accelerations of the vehicle due to an obstacle which comes up suddenly can lead to an actually undesired setting of a sporty driving style, for which reason an appropriate visual or acoustic warning indication is provided. In order to facilitate classification of driving styles, it is proposed in one variation to perform

detection of a measurement variable for the purpose of classifying driving styles only under specific driving conditions in which the driver can also actually freely determine the driving style to a large extent and to use as such measurement variables the speed of the actuation of the accelerator pedal, in particular when starting the vehicle, and/or the actuation of the brake pedal when stopping the vehicle.

In Offenlegungsschrift DE 42 15 406 A1 there is provided within a control system for shifting an automatic gearbox a driver identification device by which a driver can be classified according to his driving style infinitely variably from economical to sporty/performance-minded. Among the features which can be used as driving style features are the throttle valve position and its rate of change, the vehicle speed and acceleration, the steering angle and the state of the brake switch. These measurement variables are processed with fuzzy logic rules according to certain weightings, producing a single characteristic number, which classifies the driver in his driving style between economical and sporty. The setting of the shifting behaviour of the gearbox is carried out according to this classification.

The technical problem on which the present invention is based is to provide a method and a motor vehicle using this method, with which reliable classification of driving styles between a steady and a dynamic driving style is made possible and, using this classification, a reliable adaptation of one or more open-loop or closed-loop control systems of the motor vehicle to the respective driving style is made possible.

According to the present invention there is provided a method for gradually classifying driving styles between a steady driving style and a dynamic driving style, in which

- during driving measurement variables which are indicative of driving styles are sensed by vehicle sensor systems and

- at least one driving-style code number is determined by means of at least some of the detected measured values using a respectively associated measurement variable/driving-style characteristic diagram which has been stored in advance,

wherein an acceleration code number relating to the acceleration behaviour, a braking code number relating to the braking behaviour and a steering code number relating to the steering behaviour are determined separately.

By means of the method, the driving style is classified separately with respect to the acceleration behaviour, the braking behaviour and the steering behaviour. This procedure takes into account the fact that it is usually not possible to classify the driving style satisfactorily with a unique code number. Instead, it has become apparent that it is expedient to consider the longitudinal dynamics and the lateral dynamics separately in this respect and, moreover, to differentiate the longitudinal dynamics with respect to acceleration behaviour and braking behaviour. This is because a dynamic driving style is characterized with respect to a steady driving style by rapid acceleration and late but hard braking and high lateral accelerations are permitted when cornering. It is a fact here that a driver does not for example control the angle of the accelerator pedal, the brake pedal or steering wheel, which angles constitute his adjustment variables, but rather the control comparison takes place with the vehicle accelerations in the longitudinal direction and lateral direction, on which he is supplied with visual and haptic feedback. Consequently, the use of these features leads to a more reliable classification of driving styles than if the values of the adjustment variable are used for this. From these three detected code numbers, the information which is decisive for the respective open-loop or closed-loop control system to be adapted can then be selected in the best possible way. In comparison with the use of a unique code number for evaluating driving styles, this permits a more detailed

driving-style adaptation which is capable in particular of dealing with the specific requirements of the respective open-loop or closed-loop control system in that, in order to adapt it, only one or two of these code numbers or else the three code numbers are used in a weighting which can be specifically prescribed for the system to be adapted. Thus, different open-loop or closed-loop control systems can be respectively adapted to an optimum degree in different ways.

An embodiment of the invention in which the respective code number is formed as an average value over a prescribed number of individual code number values determined last, the individual code number values being determined at time intervals as a function of the respectively detected measured sensor values, has the advantage that a unique, singular driving behaviour, for example due to an obstacle which comes up suddenly does not immediately lead to a correspondingly unambiguous evaluation of the driving style which falsifies the classification of driving styles. Instead, the formation of average values over a number of individual code number values determined last in each case leads to a smoothing of the progression over time of the respective determination of code numbers.

A preferred manner of determining individual code number values comprises the following steps:-

- the measured sensor values are monitored for the presence of preselected enabling values for the activation of a determination of individual code number values,
- the instantaneous values of the measurement variables which are indicative of driving styles for the respective code numbers are detected as soon as the enabling values are available,
- the measured values are monitored for the presence of preselected stop values for the deactivation of the ongoing instantaneous value detection process and this process is stopped as soon as at least one of the stop values is available,

- the individual code number value is determined by comparing th detected instantaneous values with the values stored in the associated measurement variable/driving-style characteristic diagram and
- when an exceptional situation is detected, the individual code number value which has been determined is increased or decreased by an amount which can be prescribed as a function of the detected exceptional situation.

In particular, it is provided here for the determination of the individual code number values to be performed only under specific driving conditions whose presence is interrogated by monitoring corresponding measured values. In this way, the classification of driving styles can be restricted to driving conditions in which the individual driving style of a driver is most clearly expressed and is as far as possible unrestricted by external circumstances. The measured values which are indicative of driving styles are then evaluated by comparison with the measurement variable/driving style characteristic diagram stored in advance for the respective code number into an associated individual code number value for the corresponding driving style with respect to accelerating, braking or steering.

This evaluation takes place preferably using a fuzzy logic. Detected exceptional situations such as e.g. a TCR or ABS control intervention or travelling along a route with a very large positive or very large negative incline, i.e. with an angle of inclination of a carriageway which lies above an appropriately prescribable limit value can be subsequently taken into account in a predetermined way by suitably increasing or decreasing the code number.

For detecting the acceleration code number and/or the braking code number, in a further development of the invention a measurement variable which is dependent on the driving style is formed by the period in which the vehicle speed is increased or decreased by 10 km/h in each case

starting from the time of activation of the corresponding detection of the individual code number value. This is based on the knowledge that relatively small fluctuations in speed are generally not significant for the accelerating or braking behaviour but rather serve to maintain a specific speed. Fluctuations in this speed range say less about the dynamics of the driving style and more about the nervousness of the driver or a brief shock reaction. In the case of differences in speed which are substantially larger than 10 km/h the probability is very large that when accelerating a speed limit or a vehicle travelling ahead no longer permits the driver to react freely. Also in the case of braking, relatively long manoeuvres have too much ambient influence which is undesired for the classification of driving styles. The restriction of the classification of driving styles with respect to accelerating or braking behaviour to the range of change in speed of 10 km/h therefore constitutes a favourable compromise between these extremes, which compromise provides very suitable information on the driving style.

An advantageous classification of driving styles is obtained if the following criteria are used to detect code numbers, namely,

- there is no evaluation of driving actions which are detected as occurring rarely,
- there is no evaluation as dynamic of driving actions which are detected as hectic or nervous,
- selection of those measurement variables indicative of driving styles which behave integrally with respect to a driving manoeuvre, and
- there is separate treatment of manoeuvres which are detected as critical for safety.

This permits a very reliable evaluation of the actual type of driving style while largely eliminating driving actions which are brought about by situations or performed with a view to manipulation. Thus, an evaluation of rare driving situations such as e.g. reversing, is omitted.

Likewise, the estimation as dynamic of hectic or nervous driving actions which generally constitute measures which are untypical of driving style is omitted. Measurement variables which are selected as indicative of driving styles are those which behave integrally with respect to an entire driving manoeuvre and therefore cannot be manipulated, or can only be so with difficulty, by means of singular driving actions to intentionally influence the evaluation of driving styles. Furthermore, in this embodiment there is a separate treatment of manoeuvres which are detected as critical for safety in order to allow for their separate position with respect to the evaluation of driving styles. With these measures a highly precise separation can be achieved between a steady and a dynamic driving style.

An advantageous embodiment of the invention is illustrated in the drawing and described below.

The single figure shows a block diagram of part of a vehicle electrical system with control systems which adapt driving styles.

In the figure, part of the vehicle electrical system is illustrated which contains as open-loop or closed-loop control systems a traction slip control (TSC), an electronic accelerator pedal, an engine-gearbox management system (EGM) and a spring and shock-absorber system. For each of these systems a central unit 3, 6, 8, 10 is provided which, for the sake of simplicity, is also designated below as a control device in the case of actual closed-loop control systems. The TSC control device 3 controls the throttle valve and the brakes 2, the exhaust gas control device 6 controls the throttle valve 7, the EGM control device 8 controls the engine and the gearbox 9 and the spring and shock-absorber control device 10 controls the vehicle-level control system 11. On the input side the necessary output signals of a vehicle sensor system 1 are fed to the control devices 3, 6, 8, 10, the said sensor system 1 detecting the required measurement variables as they arise during driving as a result of the behaviour of a driver 5. Additionally,

the motor vehicle has an anti-lock brake system ABS (not explicitly shown).

Furthermore, the vehicle electrical system has a driving-style adaptation unit 4, the output signals of which act on the input side on input parameters of the control devices 3, 6, 8, 10 in such a way that the latter are adapted in their control behaviour to a specific driving style which lies gradually between a very steady driving style and a very dynamic driving style. Depending on the driving style prescribed by the driving-style adaptation unit 4, the control devices 3, 6, 8, 10 therefore control their respectively associated adjustment elements 2, 7, 9, 11 in different ways. Thus, when a steady driving style has been prescribed, the TSC is stable, the exhaust gas control insensitive, the spring and shock-absorber system comfort-oriented and the EGM operates according to consumption-optimized switching characteristic lines while, on the other hand, when a dynamic driving style has been prescribed the TSC has strong traction, the exhaust gas control is sensitive, the spring shock-absorber system is adjusted to sporty and the EGM behaves according to switching characteristic curves configured for sporty operation. Between these two extremes, in each case the open-loop or closed-loop control behaviour which is suitable for the respectively detected driving style can be gradually set in a number of increments or without increments.

The driving style to which the control devices 3, 6, 8, 10 are adjusted is determined with reference to selected output signals of the vehicle sensor system 1 by the driving-style adaptation unit 4, for which purpose the latter is fed with the required sensor signals which are indicative of driving styles and are given below in greater detail. The driving-style adaptation unit 4 determines on the basis of these supplied measured values the respective driving style with reference to a classification according to the method described in greater detail below. The latter is stored as a program in a memory of the driving-style

adaptation unit 4, the driving-style adaptation unit 4 also containing the other hardware which is necessary for the described classification of driving styles, is made up of customary components which are familiar to the person skilled in the art and therefore does not need to be presented here in greater detail.

For the classification of driving styles the method provides for the separate determination of a code number relating to the acceleration behaviour, more precisely to the longitudinal acceleration behaviour, of a code number relating to the braking behaviour and a code number relating to the steering behaviour, i.e. the lateral acceleration behaviour. Here, relatively high code numbers correspond to a more dynamic driving style. The measurement variables detected by the vehicle sensor system 1 as indicative of driving styles are detected for the determination of each of the three code numbers, the speeds of revolution of the front left-hand and right-hand wheels, the state of an TSC information lamp, the power-to-weight ratio of the vehicle which can be identified on-line and, optionally, the state of the reversing light. Additionally, for the determination of the acceleration code number, the prescribed throttle valve value and optionally the setting of a kick-down switch are detected and for the determination of the brake code number the state of the brake light switch and optionally information on the state of the ABS control are detected and for the determination of the steering code number optionally the steering wheel angle and likewise optionally the lateral acceleration are detected. The detections of the measurement variables which are designated as optional can be carried out here in each case with appropriate sensor systems provided these are present in the vehicle sensor system 1. Otherwise, the corresponding measured values are calculated indirectly from the measurements of the speeds of revolution of the wheels and/or the prescribed throttle valve value. Inaccuracies here do not influence the classification result significantly. If the information relating to the reversing

light is omitted, driving manoeuvres which are carried out in reverse are also classified. Although the method is not really designed for this, it does not result in a fault, or results in only a negligibly small fault.

The following evaluation procedure takes place for the determination of each code number. During driving measurement variables which are specifically selected for the individual code numbers are monitored for the possible start of a driving manoeuvre to be evaluated. After the start of a driving manoeuvre of this kind is detected, during this manoeuvre the measurement variables which are indicative of driving styles and are required for the determination of the respective code number are detected. This detection of measurement variables is terminated as soon as at least one criterion of abort criteria which are also preselected on a code number-specific basis is fulfilled. The detected measured values are then evaluated with reference to a measurement variable/driving style characteristic diagram, prescribed for the respective code number, for determining the sought, driving-style-classifying code number. Subsequently, exceptional cases which may be present are taken into account. Then, the respective code number for this code number is determined by averaging over a prescribed number of individual values determined last so that a certain degree of smoothing in the progression over time of the code number and independence from a possibly singular driving manoeuvre is obtained.

To this extent, the evaluation procedure supplies already applicable results for the case of changes occurring which are significant in the variations of the measurement variable signals. On the other hand, for journeys at constant speed on a straight route the code number value determined in this way remains constant. Therefore, the absence of such vehicle dynamics is additionally taken into account by a corresponding, general reduction in the code number in the direction of a steady driving style, this reduction algorithm only being assigned to determining the

acceleration code number and steering code number. On the other hand, for the d termination of the braking code number it is not appropriate since there is no such time behaviour here. The reduction in the code number value is limited downwardly as a function of speed to a speed-dependent minimum value so that driving at a constant but high speed with increasing speed is increasingly evaluated as a dynamic driving style.

The characteristic diagrams referred to above are realized as fuzzy-logic characteristic diagrams with two-dimensional feature space. In these characteristic diagrams, the results of different driving trials are reflected, the said driving trials being determined with a large number of different operators and as far as possible covering the entire feature space. Criteria for the selection of features, i.e. of suitable measurement variables for the classification of driving styles can also be derived from these trial runs. Thus, the precision of separation between a steady driving style and a dynamic driving one must be as large as possible. In normal road traffic many features are not very specific in terms of driving style but rather frequently dominated by the external driving conditions. This restricts the number of measurement variables which can be used for classifying driving styles and prescribes peripheral conditions which have to be kept to during the determination of a driving-style code number. The measured variables must be characterized by the driver dynamics without contradiction, at the same time hectic or nervous driver actions must not be allowed to have effect. Each feature must occur frequently enough to permit a basis for comparison to be established, only driving situations which are part of the regular range of experience being evaluated. Reversing is therefore preferably excluded since this manoeuvre is carried out rarely and is usually characterized by careful driving under difficult conditions, for which reason it provides little information on the driving style. Manoeuvres which are critical for safety, such as in the

case of TSC control, are only evaluated in the case of repetition since the first control intervention can be due to a driving mistake or to the system sensing the road grip. Furthermore, feasible features to be evaluated are only those which cannot be manipulated individually intentionally or unintentionally, integral features, e.g. averaged variables being particularly manipulation-proof over an entire driving manoeuvre. If, as an example, the locking of gears in an automatic gearbox is considered, the respective code number can increase in an undesired way if the frequency of changing gears is evaluated without considering the respective expediency. This expediency can however only be evaluated with difficulty since the reason for it cannot always be seen during the later characteristic of the sensor signal. This is taken into account here in that the locking of gears itself is not evaluated. If, after locking, an acceleration process without forced changing-down starts, the average acceleration turns out to be higher, which is reflected completely automatically with a higher acceleration code number. The results acquired in advance by means of these trial runs are, as stated, stored as advance information in the form of fuzzy characteristic diagrams in the driving-style adaptation unit 4.

Each measurement variable/driving-style fuzzy characteristic diagram is generated here by means of two sets of points with a respectively ellipsoidal domain of attraction. One quantity describes the feature range for a steady type of driving and the other describes that for a dynamic type of driving. For a measurement variable to be evaluated the distance from the generating points is determined and, from this, a degree of membership to the quantity associated with the steady or with that associated with the dynamic style of driving is determined. By means of subsequent defuzzification, in each case an individual code number value is then obtained for each driving manoeuvre to be evaluat d, which value is interpolated between the two extreme values for a steady and for a dynamic driving style.

The permitted value range of the characteristic diagrams is bounded by straight lines. An advantage of such a characteristic diagram consists furthermore in the fact that it is easy to scale in order to transform it for example to another type of vehicle with another power-to-weight ratio. For this all that is necessary is to displace the position of the generating points and the straight lines. Alternatively, it is possible to operate with characteristic diagrams with more than two input features, which is then however no longer so easy to interpret graphically. Therefore, a sequential logical connection appears more appropriate. Furthermore, in principle it is possible as an alternative to use more than two generating sets of points.

The evaluation of an individual manoeuvre supplies, as stated, an individual code number value in each case. By averaging a plurality of individual manoeuvres the progression over time of the code numbers is smoothed. In order to carry out this averaging a memory is provided which can be filled with a variable number of individual values. A respective item of memory information contains here the time of the end of the manoeuvre and the associated individual code number value. From the start of a journey, the memory is filled with each further evaluated manoeuvre up to a prescribed maximum number. Subsequently, the oldest element is always overwritten. The prescribed maximum number of memory inputs consequently determines the dynamics of the averaged code number, i.e. a relatively large maximum memory number makes the changing of the averaged code number over time slower. Furthermore, a time window is prescribed for the averaging in order to remove excessively old values so that the result remains as up to date as possible. At the same time, a minimum number of retained memory inputs greater than one is prescribed in order to prevent for example an individual measurement result alone determining the average value. Furthermore, the elimination of the respectively smallest memory element is provided as a selectable function in order to take into account the fact

that a sporty driver in traffic on the public road can frequently not carry out every manoeuvre as dynamically as he would actually like to; the number of memory inputs therefore does not drop below the minimum number. The new code number is then calculated from the respectively remaining memory inputs as an average value and the new result is logically connected to the old average value for the purpose of further smoothing.

Below, the respective averaging of the acceleration code number, braking code number and steering code number is treated in detail separately.

As a criterion for a start of a driving manoeuvre to be evaluated for the purpose of determining the acceleration code number it is tested firstly whether there is no acceleration manoeuvre instantaneously active, secondly whether the speed of change of the prescribed throttle valve value exceeds a prescribed threshold value and thirdly whether the reverse gear has not been selected. If these three measurement variable interrogations receive positive responses during driving, i.e. when the corresponding measurement variables have reached the preselected enabling values, the activation of a determination of an acceleration code number is then enabled during the subsequent driving manoeuvre. Subsequently, as measurement variables which are indicative of driving styles the following variables are determined by the vehicle sensor system 1: the period in which the vehicle speed has been increasing by 10 km/h since the start of manoeuvring; the average prescribed throttle valve value; the maximum vehicle acceleration; the maximum speed of change of the throttle valve; the TSC control time; the kick-down actuation time during the first 10 km/h of the speed increase; and the period until the prescribed throttle valve value stops increasing for the first time. The detection of these measurement variables is terminated when either the prescribed throttle valve value is withdrawn, as correspondingly monitored stop values, the throttle valve is closed, the reverse gear is selected or a second powerful

surge of fuel takes place.

The classification takes place according to the following criteria. Primarily, the initial speed of an acceleration manoeuvre is evaluated in conjunction with the period for an increase in speed of 10 km/h. A value which evaluates the driving style of the acceleration is assigned to each pair of values by means of a fuzzy characteristic diagram. The characteristic diagram is adapted to the present type of vehicle by means of the power-to-weight ratio. The characteristic diagram is characterized by the running resistances so that even at relatively high speeds the convertible accelerations lead to corresponding code number values. The starting-up range is made somewhat less sensitive since even a steady driver is carried along in the traffic flow and would be continuously over-valued without this measure. Influences of gear-changing processes are not explicitly taken into account. A dynamic driver forcibly brings about changing down even before the acceleration manoeuvre, as a result of which a faster increase in speed by 10 km/h is achieved than if the changing down was only triggered by the accelerator pedal. In order to take account of the power limit of the engine, either the average prescribed throttle valve value or the kick-down actuation time leads to an increase in the code number value. On the other hand, an excessive acceleration when travelling downhill leads to a reduction in the value of the acceleration code number. On routes with relatively low coefficients of friction the TSC control time is evaluated. Here, the procedure adopted is that the first driving manoeuvre with TSC control is not taken into account and only the subsequent manoeuvres have the effect of increasing the code number as a function of the average prescribed throttle valve value and the TSC control time. The effect of this is that the classification of the acceleration behaviour remains independent of the system sensing the grip of the road. If the speed increases by at least 1 km/h, but not beyond the limit of 10 km/h, and at the same time a TSC

control is activated, th maximum speed of change of the throttle valve is evaluated.

By reference to these criteria the associated characteristic diagram is built up, the person skilled in the art being able to perform without difficulty the implementation which is dependent on the particular application and is made concrete in value terms, for which reason more details on this do not need to be given at this point. By comparing the corresponding measured values with the characteristic diagram the respective individual code number value is obtained. The individual code number values which were determined in this way are stored and averaged in the manner described above in order to determine the acceleration code number, a time window of 10 minutes, a minimum number of associated memory inputs equal to two and, in the case of an automatic gearbox, a maximum number of associated memory inputs equal to four being selected and in each case the memory input which is smallest in value terms being eliminated. In the case of a manual-shift gearbox, a maximum number of associated memory inputs equal to eight is selected since the number of individual manoeuvres rises as a result of the manual gear-changing process.

In order to determine the braking code number, the start of a driving manoeuvre to be evaluated is detected, when, as preselected enabling values, no braking manoeuvre is instantaneously active, the brake light switch is switched on and a reverse gear has not been selected and, furthermore, it is detected that the vehicle is moving. The measurement variables which are detected for the evaluation of the driving manoeuvre with respect to the braking behaviour and are indicative of driving styles consist of the period which is required to decelerate the vehicle by 10 km/h, and of the ABS control time during the entire braking manoeuvre. The end of the driving manoeuvre to be evaluated is detected as soon as either the brake light switch is switched off, the vehicle is stationary or the reverse gear is selected.

Consequently, the classification with respect to the braking behaviour requires the vehicle to have been decelerated by at least 10 km/h. An individual braking code number value is then determined from the deceleration time for the first 10 km/h of deceleration of the vehicle by means of a weighting factor. The ABS control time leads to an increase in the individual code number value. As for the TSC control times in the above case of the determination of the acceleration code number, it is also correspondingly the case here that only subsequent manoeuvres with ABS control influence the classification of the braking behaviour. The concrete implementation in value terms can, again, be carried out by a person skilled in the art without difficulty in a manner related to the particular application in a manner which does not need to be explained in greater detail. For averaging over the individual braking code number values a time window of 10 minutes, a minimum number of memory inputs equal to two and a maximum number of memory inputs equal to four are selected. During the determination of the braking code number, the element which is smallest in value terms is not suppressed since here the effect that a driver cannot brake in a manner corresponding to his driving style because of other road users does not occur with significant frequency.

In order to determine the steering code numbers, the system concludes that the start of a driving manoeuvre to be evaluated has occurred if the following conditions are fulfilled, i.e. the following enabling values are present: no steering manoeuvre is instantaneously active, the steering wheel angle is larger in absolute terms than a threshold value which is prescribed as a function of speed, the vehicle is moving and reverse gear has not been selected. If these conditions apply, during the subsequent driving manoeuvre the following measurement variables which are indicative of driving styles for the steering behaviour are detected by the vehicle sensor system 1: the maximum lateral acceleration occurring and the longitudinal

acceleration occurring at the same time as well as the speed of the vehicle at this time, the maximum deceleration of the vehicle and the TSC control time during the entire steering manoeuvre. The end of the vehicle manoeuvre to be evaluated for determining the steering code number is detected as soon as, as correspondingly preselected stop values, either the value of the steering wheel angle drops below a threshold value which is prescribed as a function of speed, the vehicle is stationary or the reverse gear is selected.

In the evaluation for the steering classification, a value which comes as close as possible to the lateral acceleration as felt by the driver is determined from the maximum lateral acceleration which has been determined and from the associated speed of the vehicle by means of the corresponding characteristic diagram. If this value exceeds a prescribed threshold value or if the steering manoeuvre lasts long enough, the steering manoeuvre is evaluated. In addition it is necessary for the condition to be fulfilled that during steering excessively hard braking does not occur since during such manoeuvres braking operations dominate and the steering process can no longer be counted as part of a normal manoeuvre which provides information on the steering behaviour. With the result from this first characteristic diagram, the associated longitudinal acceleration is included in the calculation by means of a second characteristic diagram. A TSC control during the steering manoeuvre leads to an increase in the individual steering code number value. As when determining the acceleration code number, the first manoeuvre with TSC intervention is not evaluated here either but only the subsequent manoeuvres. In turn, without having to go into greater detail on this, the concrete embodiment in value terms of this part of the method can be left to the person skilled in the art taking into account the respective application and the customary rules of fuzzy logic. Consequently, in order to determine the steering code number averaging of the corresponding individual values by means of a time window of five minutes,

a minimum number of memory inputs of three individual values and a maximum number of memory inputs of ten individual values subsequently takes place, the smallest value being eliminated in each case.

With this specific driving-style classification which is divided up into braking behaviour, acceleration behaviour and steering behaviour the driving-style adaptation unit 4 is capable of adapting the respective control devices 3, 6, 8, 10 of associated open-loop or closed-loop control system of the vehicle in terms of their control properties to the respectively determined driving style in a selective way, depending on the control device only one or two of the separately determined three code numbers or else all three code numbers with a prescribed weighting being used to set the relevant parameters of the control devices. Of course, the person skilled in the art is capable of carrying out modifications of the arrangement described above and of the driving-style classification method within the scope of the invention, in particular if appropriate further control systems or else only some of the control systems shown can be influenced by the driving-style adaptation unit in terms of their control characteristics. According to the invention, the driving-style classification is carried out using the output signals of an existing vehicle sensor system without additional sensor systems being generally required. The driving-style adaptation unit can be supplied with selected sensor signals which are particularly informative with respect to the driving style. Consequently, the invention permits, with existing vehicle sensor systems and an additional unit which evaluates and sets driving styles, adaptation of the existing open-loop or closed-loop control systems of the motor vehicle in a selective way by means of a code number relating to the acceleration behaviour, a code number relating to the braking behaviour and a code number relating to the steering behaviour of the respective driver.

Claims

1. A method for gradually classifying driving styles between a steady driving style and a dynamic driving style, in which

- during driving measurement variables which are indicative of driving styles are sensed by vehicle sensor systems and
- at least one driving-style code number is determined by means of at least some of the detected measured values using a respectively associated measurement variable/driving-style characteristic diagram which has been stored in advance,

wherein an acceleration code number relating to the acceleration behaviour, a braking code number relating to the braking behaviour and a steering code number relating to the steering behaviour are determined separately.

2. A method according to Claim 1, wherein the respective code number is formed as an average value over a prescribed number of individual code number values determined last, the individual code number values being determined at time intervals as a function of the respectively detected measured sensor values.

3. A method according to Claim 1 or 2, wherein the following steps are carried out in order to determine an individual code number value:

- the measured sensor values are monitored for the presence of preselected enabling values for the activation of a determination of individual code number values,
- the instantaneous values of the measurement variables which are indicative of driving styles for the respective code numbers are detected as soon as the enabling values are available,
- the measured values are monitored for the presence of

preselected stop values for the deactivation of the ongoing instantaneous value detection process and this process is stopped as soon as at least one of the stop values is available,

- the individual code number value is determined by comparing the detected instantaneous values with the values stored in the associated measurement variable/driving-style characteristic diagram and
- when an exceptional situation is detected, the individual code number value which has been determined is increased or decreased by an amount which can be prescribed as a function of the detected exceptional situation.

4. A method according to claim 3, wherein the said exceptional situation comprises the presence of TSC or ABS control or an excessive angle of positive or negative gradient of the carriageway.

5. A method according to any one of Claims 1 to 4, wherein the measurement variable/driving-style characteristic diagrams are formed as fuzzy-logic characteristic diagrams, the said diagrams being generated in each case by at least two sets of points, one of which represents a steady driving style and the other a dynamic driving style, the intervals from the generating points being determined for the measured values and a degree of membership to one or other set being determined therefrom and by means of defuzzification an individual code number value which lies gradually between the value representing the most steady driving style and the value representing the most dynamic driving style being obtained.

6. A method according to any one of Claims 1 to 5, wherein, for the determination of the acceleration code number and of the braking code number, a measurement variable which is indicative of driving styles is given by

the time in which the speed of the vehicle increases or decreases by 10 km/h starting from the time of activation of a determination of an individual code number value.

7. A method according to any one of Claims 1 to 6, wherein the following classification criteria are used for determining code numbers:

- there is no evaluation of driving actions which are detected as occurring rarely,
- there is no evaluation as dynamic of driving actions which are detected as hectic or nervous,
- selection of those measurement variables indicative of driving styles which behave integrally with respect to a driving manoeuvre, and
- there is separate treatment of manoeuvres which are detected as critical for safety.

8. A motor vehicle with

- at least one open-loop or closed-loop control system which adapts driving styles, comprises the vehicle sensor system, an adjustment element and an open-loop or closed-loop control device, the adjustment element being controlled by the open-loop or closed-loop control device as a function of output signals of the sensor system, and
- with a driving-style-adaptation unit, to which sensor system output signals which are indicative of driving styles are adapted to be fed and which determines an associated driving style as a function of the supplied signals, and produces output signals which are dependent on the determined driving style in order to set input parameter values, which influence the open-loop or closed-loop control behaviour, for the open-loop or closed-loop control device,

wherein

- the driving-style-adaptation unit determines the respective driving style by means of the method

according to any one of Claims 1 to 6, the said unit producing the output signals for setting the input parameter values for the open-loop or closed-loop control device as a function of the acceleration code number, braking code number and/or steering code number, in a way which can be prescribed specifically respectively for the open-loop or closed-loop control device.

9. A method for gradually classifying driving styles between a steady driving style and a dynamic driving style, substantially as described herein with reference to and as illustrated in the accompanying drawing.

10. A motor vehicle adapted to carry out the method of claim 9, and substantially as described herein with reference to and as illustrated in the accompanying drawing .

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10 APRIL 1996

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) WPI

Documents considered relevant following a search in respect of Claims :-
1 to 10

Categories of documents

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&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2266957 A	(DAIMLER BENZ) page 2 line 22 to page 3 line 1	1 and 8 at least
X	EP 0542421 A2	(S KONDO) abstract	1 and 8 at least
X	US 5189621	(HITACHI) column 2 line 11 to line 28	1 and 8 at least

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